14: Exoplanets

Learning Objectives

- Describe the methods of detecting exoplanets including the transit and Doppler methods.
- Describe how exoplanets can be detected through direct imaging.
- Describe the sizes, orbits, and properties of many exoplanets that have been detected.
- Understand how future detection methods may find more Earth-like exoplanets.

Astronomers have wondered whether other worlds existed beyond our own. Giovanni Bruno, a Dominican friar and astronomer, theorized in the 16th century that the stars could be suns like our own with planets orbiting. However, Bruno was the exception for centuries. Most ancient and medieval observers did not think stars were like the Sun because Sun is so much brighter. Most assumed that they were just points of light and had no idea how big or distant they were.

Giordano_Bruno_BW_2.jpg

Christian Huygens (1629–1695) used holes drilled in a brass plate to estimate the angular sizes of stars. His results demonstrated that, if stars were the same size as the Sun, they must be at great distances. Galileo also argued that the stars must be much further away that assumed due to the lack of observed parallax.

Even after the fact that the stars are like the Sun, the question of whether they had planetary systems of their own remained an open question for generations. The computer models of nebular contraction supported the belief that planetary systems should be common. As a cloud contracted and its rotation rate increased, protoplanetary discs appeared an inevitable result. Despite their best efforts, repeated observations failed to uncover evidence of extrasolar planetary systems.

The problem came down to a question of brightness and distance. A Sun-like star is about a billion times brighter than the light reflected from its planets. Planets orbit close to their stars, relative to the distance from us to the star. Trying to pick out the light reflected off a planet is akin to trying to find a firefly next to a searchlight. Discerning the tiny angular separation between a star and a planet orbit it is like being in San Francisco and trying to see a pinhead 15 meters from a grapefruit in Washington, D.C.

All of this changed in 1995 when two astronomers, Didier Queloz and Michel Mayor, announced the discovery of 51 Pegasi b, the first confirmed planet orbiting a star other than our soon. Soon, astronomers found other exoplanets and over the past few decades, the search for exoplanets have become one of the most vibrant and exciting fields of astronomy. The International Astronomical Union has established a naming convention by adding a letter after the name of the parent star. The letter “a” is reserved for the brightest object in the stellar system, i.e., the star. The first planet discovered is assigned the letter “b”, the second “c”, and so on.

Since the discovery of 51 Pegasi b, thousands of exoplanets have been confirmed, with thousands of more candidates awaiting confirmation. The Kepler mission, an orbiting infrared telescope dedicated to searching for exoplanets found over 2600 exoplanets during its nine-and-a-half-year operation. Initially, the first exoplanets were “**hot Jupiters**,” that is, large gas giants with orbits close to their host star. These planets were the easiest to detect given the techniques and data available at the time. Since then,

planets ranging from smaller than the Earth to more massive than Jupiter have been found. Most planets detected to date fall in a range of masses between the of Earth and Neptune. Astronomer have labeled these worlds “**superearths**.”

Image credit: https:/commons.wikimedia.org/wiki/File:Clear_to_cloudy_hot_Jupiters.jpg;
